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Research on Comets, Meteors, and Interstellar Matter

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Paul Harteck, Principal Investigator

R. R. Reeves, Jr. and E. W. Albers

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The purpose of our present work is to investigate the condensation and evaporation of gases in interplanetary and interstellar space on meteoritic and cometary matter. The initial studies of the various parameters involved including solar radiation intensities, condensation rates and equilibrium temperatures of particles under various conditions indicated that the thermal evaporation process might not be the major contributing factor for the kinetic behavior of the system. On the contrary, it appeared that under certain conditions the absorption of solar ultraviolet light on the surface could cause dissociation or detachment of molecules or radicals which would compete strongly with thermal evaporation. Therefore, our initial experimental efforts have been directed along these lines in order to determine if such interactions between ultraviolet light and the absorbed particles actually occur and to obtain an idea of the efficiency of such processes.

Several ultraviolet light sources were used including a standard Hanovia lamp with the Hg 2537 Å line and the 2062 Å line of iodine from the lamp developed in our laboratory. An apparatus was constructed to operate under high vacuum (10^{-9} - 10^{-7} Torr) with a cooled surface (63.5 - 77.4° K) which could be exposed to the ultraviolet radiation. An ion gauge and a residual gas analyzer were incorporated to determine any interactions occurring. The results will be formulated into a paper which will be submitted for publication shortly. However, a brief mention of the results for a particular example may be of interest. In the case of H_2S which was frozen out on the surface, irradiation by the 2537 Å resulted in both photodissociation and photodetachment. However, at 2062 Å mainly photodissociation occurred. The photodissociation was evident due to the increase of H_2 and the development of a sulfur residue on the surface. Photodetachment was evident as an overall increase in the H_2S pressure in the system which was not due to heating as was shown by several techniques. It is not evident at present whether one photon will simply detach one particle or many since each photon has more than ten times the energy for this detachment process. The dissociation energy, however, is comparable to the ultraviolet energy and therefore not more than one dissociated particle is expected for one photon absorbed.

The work is continuing along these lines to further elucidate the mechanism.

Chemical Reactions in Rarified Atmospheres:

Earlier we had been sponsored by Air Force Cambridge to investigate the kinetics of recombination reactions, and associated light emission at very low pressures of the order of a few microns. This kinetic study was originally performed in connection with the problem of night sky illumination due to the release of certain chemicals such as NO, SO and metal organic compounds.

Recently, a controversy has arisen which denied the two body combination process almost categorically for a series of recombination phenomena involving the NO-O atom and SO-O atom reactions. At a recent meeting at Durham sponsored by ARPA, ONR and AROD, this controversy became stronger and it appeared that the problems discussed are of basic importance for the behavior of many species in rarified atmospheres. A copy of the paper we presented at this meeting is attached.

We have studied these phenomena in several different experimental arrangements and under a variety of different conditions, and it looks as if we are on a sound basis, and that at low pressures, the two body process for light emission does become the dominant process in many cases. We have investigated this for the NO + O, and the SO + O system and are now investigating the N + N system. The release of metal-organo compounds in the region of 150 KM with a long-living bright luminousity gave additional evidence, that a two-body recombination process coupled with light emission is indeed operative.

This line of research will be continued until the nature of the basic reactions are entirely clarified. A paper on this subject will be sent to you shortly.